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OZONE MEASUREMENTS WITH ROCKET-BORNE OZONESONDES

By

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ABSTRACT

A rocket-borne ozonesonde has been developed which utilizes the chemiluminescent principle for the measurement of the ozone concentration in the atmosphere. This has been fired with the ARCAS rocket at White Sands Missile Range, New Mexico. The instrument, as it descends with the parachute, measures the ozone concentration. In addition to the main peak ozone concentration generally found near 22 km, a secondary peak has been observed close to 40 kilometers. A gross detailed structure of ozone distribution in the upper stratosphere has been measured which could not be obtained by the Umkehr method.

ACKNOWLEDGEMENT

I am grateful to Dr. V. H. Regener of the University of New Mexico at Albuquerque for suggesting the sampling procedure and also for supplying the chemiluminescent discs for the instruments.

CONTENTS

INTRODUCTION

In recent years knowledge of the vertical distribution of atmospheric ozone has been considerably increased, especially from data obtained by balloon-borne ozonesondes. The chemiluminescent-type ozonesonde developed by Regener (1960, 1964) and the bubbler-type electrochemical ozonesonde developed by Brewer and Milford (1960) are being used extensively for detailed measurements of the vertical ozone distribution. These balloon-borne sondes do not reach the top of the ozone layer, and the ozone concentration in the upper layers is evaluated by the Umkehr method. The need for an ozonesonde capable of measuring the complete ozone distribution in the atmosphere is an obvious one. The Regener chemiluminescent ozonesonde being a dry chemical instrument is quite suitable for adaptation to use in a small rocket.

A rocket-borne ozonesonde was developed for use with the ARCAS rocket system, and test firings have been conducted at White Sands Missile Range (WSMR), New Mexico. These sondes reached well above the stratopause and measured the ozone concentration while descending on a 15-foot diameter parachute. The circuitry of the photomultiplier tube has not been changed from Regener's original balloon-borne ozonesonde, and the Delta telemetry system (Clark and McCoy, 1965) operating at 1680 megacycles and using the AN/GMD-1 ground station has been adapted to recover the data.

INSTRUMENT

The rocket-borne ozonesonde (Figure 1) consists of three main parts: power supply, photomultiplier tube and sampling chamber, and telemetry circuit. The sampling chamber (Figure 2) consists of two concentric cylinders each having four windows of equal dimensions. The inner walls of the sampling chamber were painted with the chemiluminescent material. A photographic shutter is mounted at the bottom of the inner cylinder and a chemiluminescent disc is placed on the top, facing the shutter. The photomultiplier tube and associated circuitry are potted in a black silicone rubber and mounted below the sampling chamber. A rotary solenoid, mounted close to the telemetry circuit, controls the movement of the outer cylinder. When the outer cylinder of the sampling chamber is rotated to close the windows of the inner cylinder, the photographic shutter opens simultaneously, thus allowing the photomultiplier tube to see the chemiluminescent disc. A separate battery power (18 volts) required to actuate the solenoid is potted next to the photomultiplier tube.

A sequence timer in the ozonesonde actuates the rotary solenoid which in turn rotates the outer cylinder to take an ozone sample. The photon yield from the chemiluminescent disc is monitored by the photomultiplier tube, and the output is connected to the transmitter which operates at a carrier frequency of 1680 megacycles. In addition, an ozone zero signal and a temperature signal are briefly transmitted in a sequence. A 10-mil-diameter bead thermistor (Figure 1) with a thin-film mount is used to record atmospheric temperature.

The instrument is calibrated before launch by the use of an ozone generator (Regener, 1964) for absolute measurement of ozone concentration in the atmosphere. Ozonized air of a known concentration is injected into the sampling chamber (which is enclosed in a jacket) and sensitivity is set in the proper range.

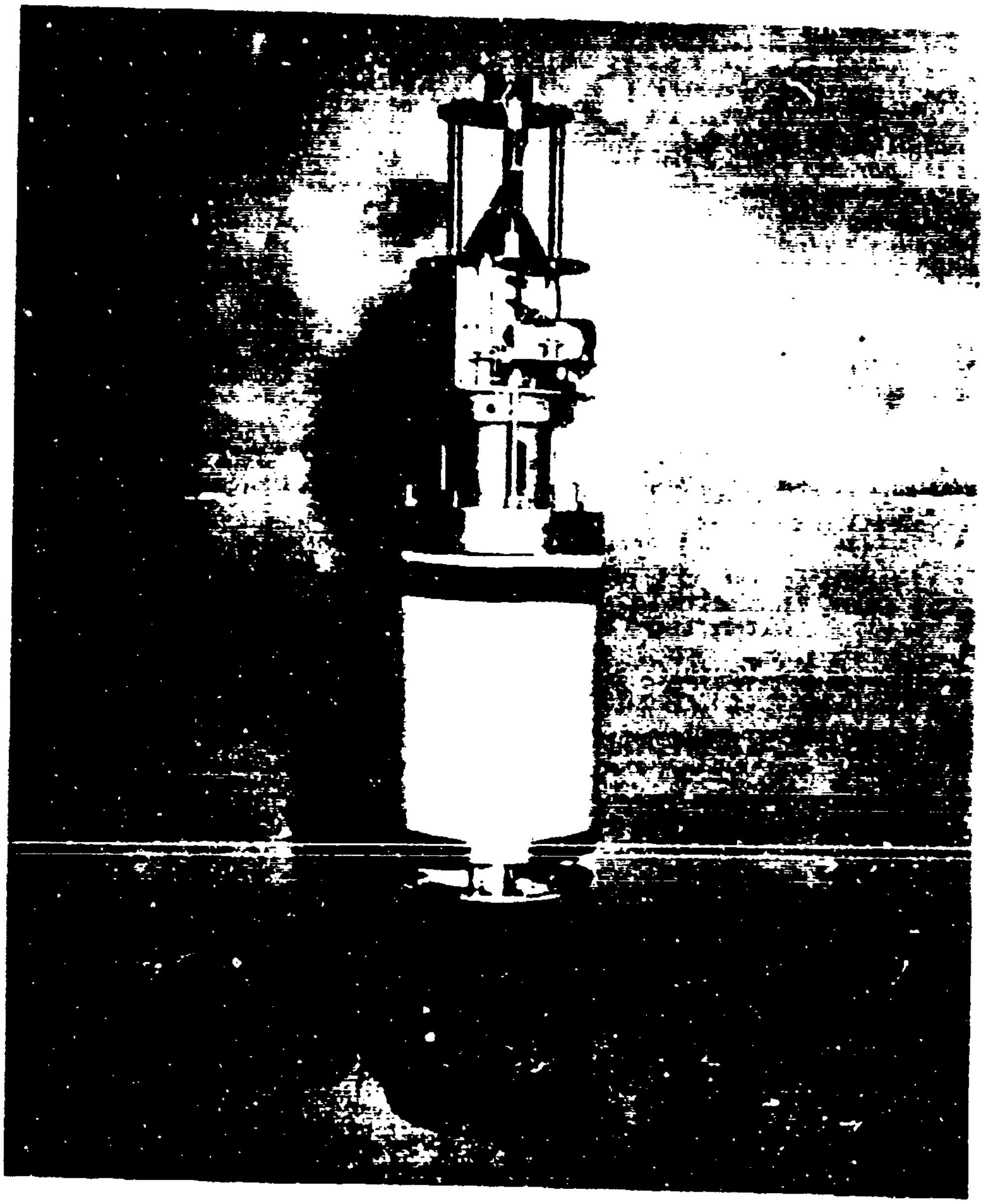

Figure 1. Rocket-borne ozonesonde.

Figure 2. Sampling chamber.

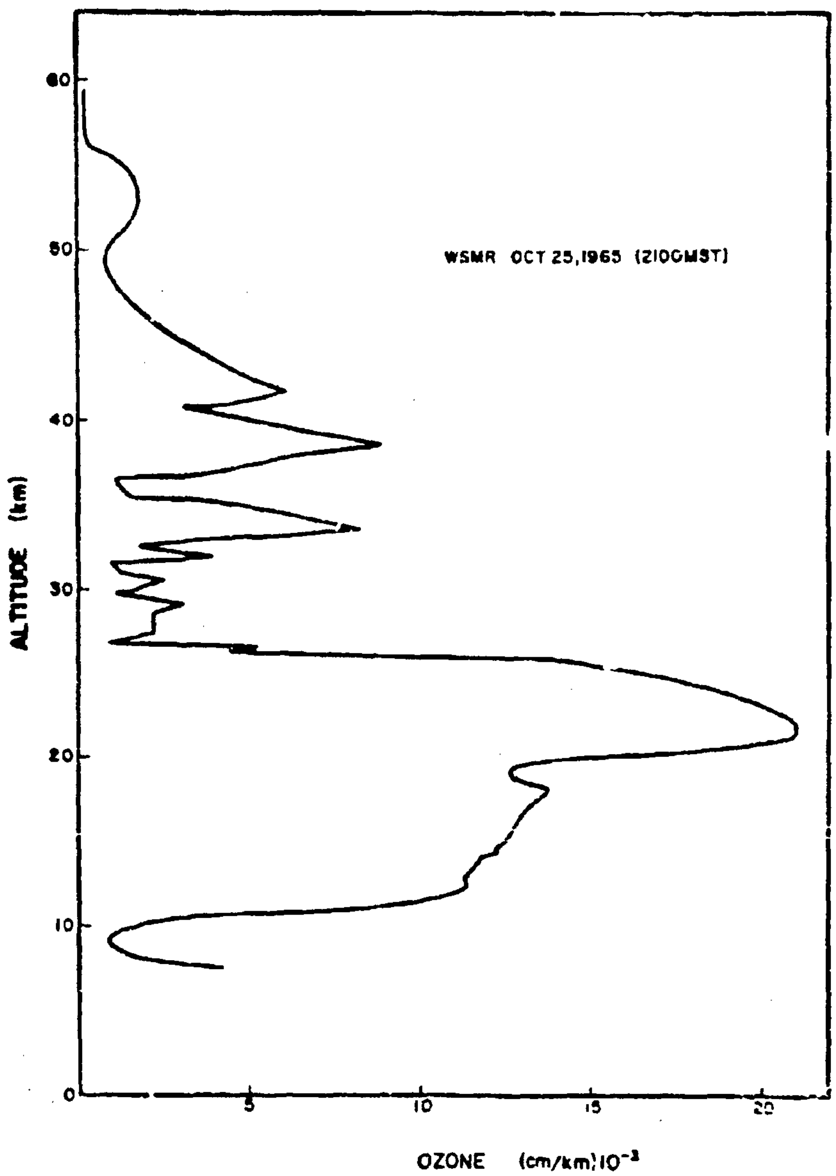

Figure 3. Ozone distribution with height.

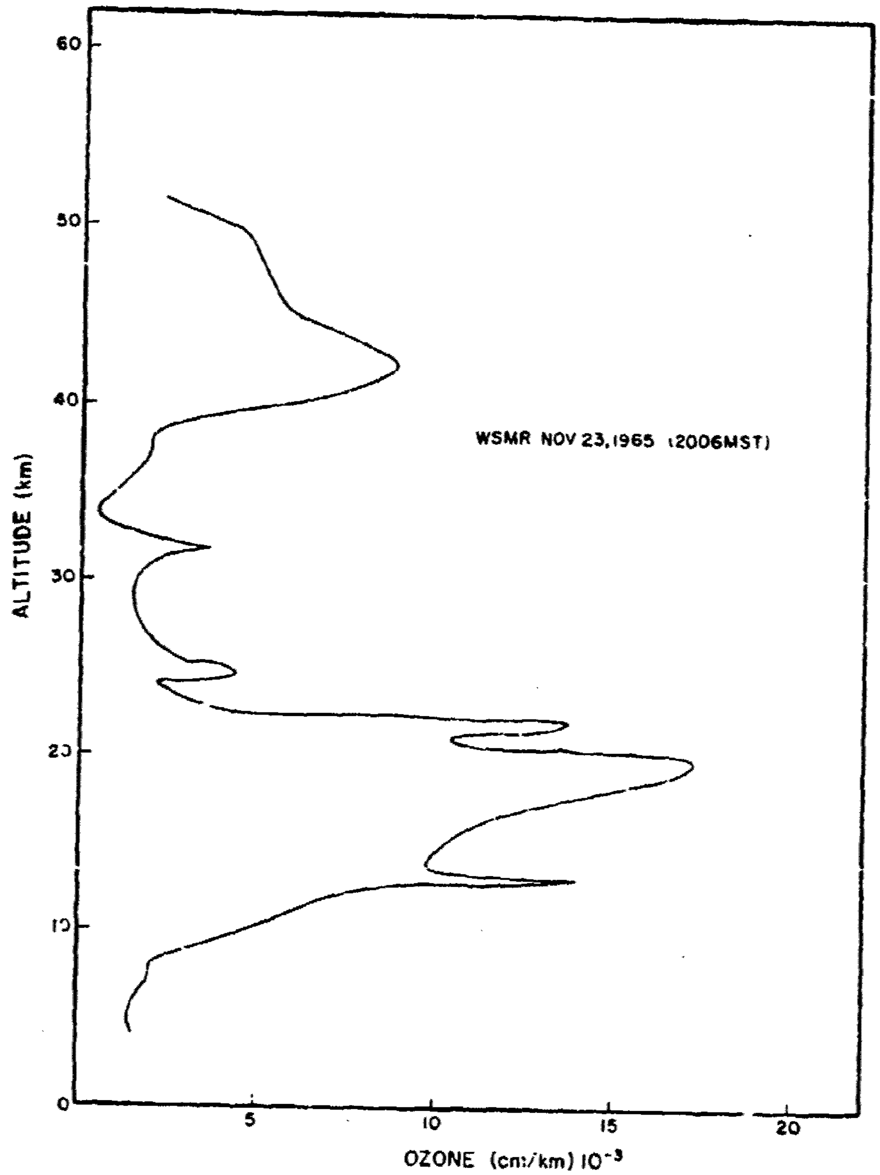

Figure 4. Ozone distribution with height.

The ozonesonde is deployed from the ARCAS rocket at apogee (approximately 130 seconds after launch), the nose cone falls clear, and the instrument returns to earth on a 15-foot-diameter radar-reflective parachute. The radar track of the parachute yields wind data while the temperature and ozone data are received by the Rawin set AN/GMD-1 receiver. As the payload descends on the parachute, ozone concentration is sampled every twenty seconds. The instrument package weighs 3½ kg and the fall rate is approximately 120 meters per second at 50 km altitude and 30 meters per second at 30 km altitude.

RESULTS

The rocket ozonesonde firings completed thus far were scheduled during dark nights to minimize contamination of the photomultiplier output by stray light. The data reduced from October and November firings are presented in Figures 3 and 4. These data show considerable variations in the ozone concentration in the stratosphere which could be attributed to atmospheric conditions. In addition to the peak ozone concentration generally found near 22 km, a secondary peak of smaller amplitude is observed close to 40 kilometers. The higher altitude peak may be considered to be a Chapman peak and the lower as a storage peak. The loss of ozone in between the two peaks could be due to the stratospheric aerosols as suggested by Kroening (1965). Another interesting point shown in the data is the decrease from 22 km to less than 20 km in the height of the main ozone peak during a month's time.

Figure 5 shows the temperature profile as obtained with the bead thermistor on October 25, 1965, 2100 MST. The bead thermistor was not mounted on the November firing so that the frequency of ozone observations could be increased.

The rocket ozonesonde has sufficient resolution to measure the detailed structure of the ozone distribution in the upper stratosphere. The data obtained do not agree with the profiles evaluated by the Umkehr method in detail; however, the total amount of ozone found by integrating on these days agrees very well with that obtained by the Dobson spectrophotometer at the corresponding latitude and time of the year. The heights of the main ozone peaks on these days also agree favorably with those obtained by the balloonsondes.

CONCLUSIONS

The chemiluminescent measurement technique has permitted the monitoring of ozone concentration in higher altitudes of the atmosphere and has given the detailed structure of the ozone distribution in the upper stratosphere. Sufficient observations have not been made to draw detailed conclusions; however, in all the firings, a secondary peak in ozone concentration has been observed around 40 kilometers.

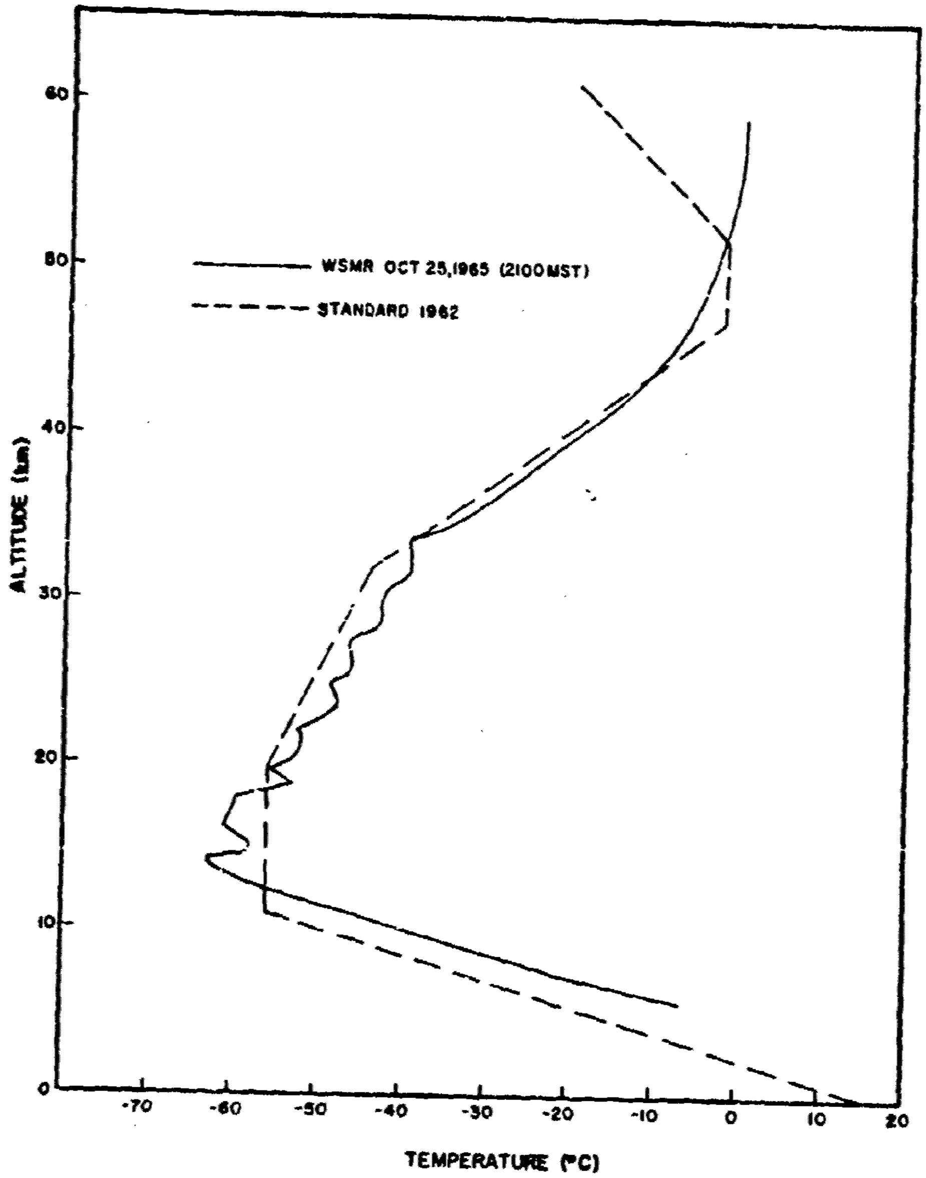

Figure 5. Temperature over White Sands Missile Range.

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13. ABSTRACT

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